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ABSTRACT

The MICRO-CMI system designed at the University of Wisconsin combines the grouping, diagnosis, and prescription functions of two previously designed systems, with the additional dimension of a sheet scanner to input grades and to score tests. Moreover, the user may specify a unique program of studies for each student, thus enabling the support of a special education curriculum designed around Individual Education Programs (IEP). The MICRO-CMI computer in the school offers online generation of results, reports, listings and grading, and operates more efficiently than the normal time-sharing system. Since the MICRO-CMI programs have been designed in a modular fashion, new functions can be added with a minimum of effort. Available for distribution on magnetic tape, the computer programs are coded in FORTRAN for a DEC LSI-11 using the RT-11 operating system. Because of the nature of the programming techniques applied and the amount of mass storage required, attempts to implement this program on APPLE, TRS-80, or other small eight-bit computers is not recommended. Sixteen schools in Wisconsin and Illinois participated in a pilot test of the system. (MER)

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AN OVERVIEW OF MICRO-CMI

by

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Report from the Project on
Microcomputer Managed Instruction

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Wisconsin Research and Development Center
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Abstract

The past year has seen the development and refinement of a Computer Managed Instruction (CMI) program on a microcomputer. There are several factors which have made the accomplishment possible at this time. First, the earlier development of two CMI systems at the University of Wisconsin provided an excellent knowledge base from which to begin. Second, the emergence of low cost hardware with significant mass storage capability provided the necessary hardware. Third, the use of hardware with a mature operating system and development support software utilities enhanced the scope and speed of the project. Fourth, the availability of experienced test sites provided timely, helpful, and relevant feedback. The purpose of this study is to indicate the nature and scope of the development effort.

The remainder of this overview briefly describes the antecedent projects, the current development effort, the rationale for use of a microcomputer, hardware selection concerns, a system description, and some important design considerations.

Project History

The MICRO-CMI project has it roots firmly established in two separate CMI efforts at the University of Wisconsin. The efforts of the Wisconsin R & D Center began in 1972 with an initial program designed to support the management of the Wisconsin Design for Reading Skill Development (WDRSD) and the Development of Mathematical Processes (DMP) project. Work with the Duluth and McFarland schools proved the validity of the idea. The initial versions of the system were implemented on a Datacraft and Univac Computer located at the university and on the Duluth Univac Computer. The system became known as the Wisconsin Student Information Management (WIS-SIM) system. The salient findings of early WIS-SIM field tests revealed the value of individual and multiple performance reports, the ease of entering grades through the keyboard or scanner, and the efficiency of the grouping function. The early version of WIS-SIM was particularly useful to schools using the the concepts of Individually Guided Education (IGE). The classroom management information helped to relieve the clerical burden associated with an individualized program. The grouping function proved extremely useful by providing the teacher with a list of students ready to work on specific elements of the curriculum, thus saving hours of work in both record-keeping and analysis for grouping purposes.

The field tests resulted in a decision to implement a generalized CMI, one which would support multiple curricula through one program and be implemented on a larger time-sharing machine. The University of Wisconsin Univac Computer was selected because of its proximity to the project, quality of service, and the broad scope of the time-sharing service offered. Field tests with this system revealed that the system was highly valued by the teachers, but that the cost of utilization in a time-sharing environment was prohibitive. A test implementation in the Denver Public Schools revealed that the cost to the district would be $13,000 per school each year if implemented district-wide. Experience in Madison revealed that costs could run between $5,000 and $30,000 per year depending on the number of curricular programs implemented and their level of use.

Management of Instruction with Computer Assistance (MICA) was a concurrent CMI development at the University of Wisconsin. This project, while remarkably similar in many aspects to WIS-SIM, had a different thrust. In WIS-SIM the grouping aspect of the educational process was emphasized. MICA was a file folder approach to individualization wherein each student was viewed as progressing along lines probably completely independent of others in the class. MICA developed relatively cost effective ways of implementing a comprehensive CMI system designed to support a mathematics curriculum. Version VI of the system was generalized to

support additional curricular areas, and the database technologies were employed to manage a complex Teacher Corps Project.

It was the combined experience and learning in the above projects which led to the system specification paper for MICRO-CMI, (McIsaac & Baker, 1978). This document indicates the scope of the MICRO-CMI project, and the order of program development. The components of WIS-SIM and MICA have been incorporated, and the program is implemented in sixteen schools in Wisconsin and Illinois. The system includes the grouping function of WIS-SIM, the diagnosis and prescription associated with MICA, and the use of a sheet scanner to input large numbers of grades and score tests. Moreover, the user may specify a unique Program of Studies for each student, thus enabling the support of a special education curriculum designed around Individual Education Programs (IEP). The remaining sections of this paper will address a number of issues associated with this development. The most common encountered is, "Why implement CMI on a microcomputer?" The question is answered in the next section.

Why a Microcomputer

There are four identifiable reasons for implementing CMI on a microcomputer system--cost, control, access, and convenience. The early field tests, particularly with

WIS-SIM, revealed a high cost for program use over a time-sharing network. CMI programs are not computer intensive, but they do require significant amounts of computer connect time. The time required to print reports and respond to the dynamic demands of teachers requires a system that is easy to use and available most of the time. The experience in Denver revealed the only cost effective way to implement the system would require off-line sheet scanner procedures. The turnaround time for a given request would be approximately one week, and teachers would be limited in the number of requests they could make of the system. Cost was estimated to be about $13,000 per school. The experience in McFarland was even more revealing. McFarland teachers had helped design CMI and were able to significantly test it. McFarland ran three curricular programs in a time-sharing environment including math (DMP), reading (WDRSD), and science (SAPA II). The cost to the research project was equivalent to $23,000 per year in computer time over and above the cost of program development. This high cost of program use indicated failure to produce a product which could be acquired and implemented by a large number of school districts. The use of a microcomputer offered a potential alternative. The microcomputer, which costs $15,000 to acquire and $2000 per year to operate, will cost a school $25,000 to use for five years. The time-sharing

system that costs $20,000 per year will cost $100,000 for the same period of time.

The second factor guiding the decision for use of the microcomputer was user control. CMI, when operational on a time-sharing system, imposes down times that can not be controlled or resolved by the school staff. The down time or communication problems can be caused by the school's terminal equipment, the telephone company's network, or the time-share vendor's computing equipment. The process of identifying the problem area can be time consuming and frustrating. If the problem exists in the computer or the telephone network, the school staff has very little control over the resolution of the problem. When the whole computing system is in the school, indeed fits on a single desk, the school is in complete control. If the system fails to operate as specified, there is little doubt that the problem is in the school's computer. There are no questions about telephone reliability or about the time-share computer. Any problem must be in the school's computer room. Most temporary computer problems can be eliminated by turning the machine off and restarting it. When the computer is located in the school, teachers or aides can easily perform this "reboot" procedure. (Reboot is the same as restart.)

When the system is installed on a microcomputer, the user has complete access to the system. The decision to

work late or print report cards all day is not a function of "better rates at night". Priority decisions are made on the basis of instructional needs, administrative needs, or available time, not cost. Also, the user is not faced with the discouragement of high cost long runs. The more a time-shared system is used, the greater the overall cost, since the unit cost is constant. When a school has a microcomputer dedicated to a single application, more processing reduces the unit cost. This is a big incentive to make maximum, rather than minimal, use of the system. The speed of transmission is a very significant factor. The terminal presents information at a 19,200 baud rate, or nearly 2000 characters per second. At this rate of speed, the program is virtually conversational. As a result, much more information can be processed in a given period of time. The programs are designed to provide on-line instruction, and the speed of transmission does not interfere with processing. Users spend far less time looking up information in manuals.

A district owned and operated microcomputer is more convenient. The school staff does not have to be concerned about log-on procedures, printing large batch jobs on a remote computer, or coordinating the responsibilities of the telephone company, the computing center, and the local staff. Nor does the school staff need to make decisions which conform to time-share vendor or telephone company

priorities. There are fewer people involved in a locally based operation, which the user finds to be a much simpler situation.

The small, dedicated, locally based microcomputer seems to be more reliable. Down times will probably be of a longer duration on a locally based micro, but they tend to be less frequent. The school staffs who have microcomputers in their CMI operation make far fewer contacts with the R&D Center staff than they did on a time-sharing system. During operation on the time-sharing system, we could expect at least one call each day regarding the operation of the system from each school. The schools using MICRO-CMI rarely need direct consulting support.

Given the power of the new microcomputers and the relatively high cost and inconvenience of time-sharing, the most reasonable approach to the management of instruction is through a school based computer designed to store student data, score tests, and provide timely reports to staff, parents, and students.

Software Specifications

The system was designed for ease of use, and its most prominent characteristic is the menu selection. Each of the functions available in the system is presented to the user in a sequence of menu selections. The selectable functions are shown in a logical sequence with related

options clustered together. The following discussion describes the full scope of available options, the manner in which they are presented to the user, and the rationale behind each capability.

The human factor led us to develop a menu driven selection. The user reviews sets of linked menus and chooses the desired function by number. Incorrect responses are simple to trap; consequently the user sees a safe and forgiving computer. Users make significantly less use of documentation because of the menu display and the on-line explanation and documentation. The high baud rates for display make it possible to present high volumes of information without inconveniencing the user. A page of information takes less than a second to display.

Students may be identified in the database in several ways. They may be included in a list which represents a unit (team). The unit may include a number of homerooms which are taught by the team of teachers. Students are also identified in connection with their homeroom assignments. The reports and lists available from the system can be generated by homeroom or unit. The unit or homeroom specifications usually reflect a semester or annual assignment. MICRO-CMI also supports the creation of temporary instructional groups which can be formed and deleted dynamically. Once instructional groups are formed,

the computer will keep track of each group so that grading and report generation may be accomplished by group.

The list of functions and report capabilities follows:

1. Performance Profile Reports

The Individual Performance Profile reports provide information to the teacher, student, or parent regarding the progress of each student. Individual pupil progress is reported in accordance with specifically requested topics or between specific dates. Teachers also have access to a report which summarizes the progress of all students in the program across all objectives. The four performance reports which can be generated regarding student progress are:

1. Multiple Performance Report
2. Individual Performance Profile
3. Individual Achievement Profile
4. Individual Student Grade Summary

2. Grouping Operations

The grouping functions of the MICRO-CMI give the user the opportunity to dynamically form and reform groups of students for the purposes of instruction. The commands within this function provide recommendations for grouping patterns, let the user form and eliminate groups, and provide various lists of student groups. The grouping function works in conjunction with scanner grading. Groups of students can be graded on a single scan sheet if the scanner option has been implemented. The four types of reports generated from the grouping function are:

1. Grade Summary
2. Grouping Recommendations
3. Omissions List - Students Not Recommended
4. Lists of Student Groups

3. Grading

The grading function is the primary basis for entering student grade information. Grades may be entered in four ways. Manual grading enables the entry of grade data through the keyboard for individual students on specific topics. Macro grading enables the entry of many grades for students simultaneously. Typically, this function would be employed for a large group of students who have all mastered a given topic at the same time. Scanner grading enables the entry of a group of students' grades from a scan sheet. Test scoring supports the grading of tests and automatic entry of

data into the student record when desired. When grades are entered via the keyboard, they may be prompted by unit, homeroom, or by group. Grades may be given across curricular areas for a given student, or across students for a given curricular area.

The grading structure is defined by the user and may contain up to 20 different grade identifiers and numeric grades from 1-99. A table of values equates the letter and numeric grade information, and each grade may be assigned a value, or weighting for maximum flexibility.

The test items must be equated to the objectives listed in the curriculum database in order to implement the automatic test/grading function. The user has the option of adding a diagnosis and prescription file which produces a recommended "next step" for students after the tests have been scored. The user can request an audit of the grades which have been entered.

4. Database Maintenance

The database maintenance routines provide for the entry of new students and the deletion of students who have left the school. Students must be specifically entered into any of the 37 possible programs supported by the system. (Each separate program is contained on a separate curriculum disk.) The system checks to determine if the proper curriculum disk is in place and permits the user to move disks in and out of the system while the program is running. Specific reports which relate to the data base maintenance are generated in the section on listings.

5. Listings and Reports

Various lists available from the system include student information, teacher information, and curricular information. Lists of students by unit, homeroom, or school can be requested. Teacher information lists indicate the name of the teacher, unit membership, and homeroom responsibility. Grouping information is also available from this portion of the program.

6. Program of Studies

The program of studies function enables the recording of a specific program for each individual student. This function is designed to be particularly useful with a special education curriculum. The IEP can be viewed as a sequence of objectives defined in the special education curriculum. Records of individual student progress then

yield reports which indicate progress in the special education program. The program of studies is also used as a forward prescription in the diagnosis and prescription function of MICRO-CMI. A series of reports can be generated which indicate the progress students have made on their individual programs of study.

7. Curriculum Maintenance

MICRO-CMI has been designed to accept any objective based curriculum. The curriculum maintenance functions enable the implementation of a preset curriculum, the development of a new curriculum, or the modification of an existing curriculum. This extremely important function permits the support of locally developed individualized programs as well as those which are commercially available.

8. Diagnosis and Prescription

The test file can be linked to the curriculum base and a file containing available school resources. When this feature is enabled, the system will evaluate the student's progress and prescribe that specific elements of the curriculum be pursued. This capability requires the creation of additional files containing the diagnosis and prescription requirements.

Critical to any system operation is the concept of "backup." Following the entry of data into the system, it is important that the user copy the information within the database onto a "backup disk." The system provides automatic procedures for backup to ensure against lost data. The backup procedures are designed to be easy to implement, and the user is not required to be a computer specialist.

In order to implement the above specifications on a microcomputer with 2.5 million bytes of mass storage, several design considerations were important. It was important to maximize the number of students and the amount of information that could be retained on each student's

progress. Moreover, it was important to minimize the time required to access any individual student's record. The following paragraphs describe our solutions to these problems.

Our objective was to support 1000 students (800 per curriculum grade disk) and to record 250 grades or objectives per child. In order to maximize the information in the student record, we designed an automatic packing feature to eliminate the noncurrent grades for the lowest level objectives. These grades are only retained for the period they are active. At the end of each period, grades are summarized at a higher level, and the student record is condensed or packed. This program option allows the maintenance of information on as many as 2500 objectives per student per curriculum.

This packed record was an important design consideration. When using larger mainframe computers, we were tempted to simply enlarge the file. With the microcomputer's limit on mass storage, we had to make careful compromises. The experience of our pilot schools indicated that storing very detailed information over extensive periods of time was unnecessary.

To store the information on multiple curricula, the system locates students' grade records on separate disks for different curricular areas. Math, reading, social studies, physical education, and the science program will

not all fit onto one floppy disk. The school must maintain a separate disk for each of the different curricular programs. The ease of placing disks into the computer and error checking for the proper disk access indicates little trouble in moving disks.

Disk access tends to be a little slower on the floppy disk, and it is important to build algorithms which compute addresses rather than search through files. The simple hash coding of ID codes provides virtually instantaneous access to student data. Consequently, it is possible to enter the update immediately into the student record. Intermediate files and batch runs are not necessary, and the user is not required to wait for output, other than the time it takes to print the report.

In the design of MICRO-CMI, the organization of information on the floppy disks was carefully planned. Each diskette holds 1.25 million bytes (characters) of information. Since the disks can be easily removed and replaced, information stored on the disks had to be optimized so the necessary information would be available for every function. The project staff has attempted to put, together on a disk, those files of information that application dictates should be together. Consequently, the basic student, school, group, teacher, and curriculum information is stored on a single disk. This disk also contains the programs necessary for the operation of MICRO-CMI. The second disk contains the

curriculum detail, prerequisite file, and student grades. Using this pattern, one can exchange up to 37 different curriculum disks for each school disk. Only the data required for the given function is in the computer at a given time. In this way the computer can effectively manage far more data than is on-line on any occasion.

The software specifications are an attempt to establish a useful, interactive, and responsive classroom data management procedure on an inexpensive microcomputer. There are some big advantages to using a computer dedicated to a specific task. The system is more reliable and less complex. The users' procedures for accessing the system can be simple and focused on the specific application. Any system, however, is no better than the hardware for which it is designed. The next section indicates the hardware necessary to implement MICRO-CMI.

Hardware Specifications

Considerable thought and experimentation went into the hardware recommendations. Early (1975) work indicated the viability of MICRO-CMI on an ALTAIR microcomputer. This was followed by tests on a variety of microcomputers, and the final decision was for a Digital Equipment Processor using the RT-11 operating system. The minimum hardware specifications of the system include the following:

CPU - LSI-11
MEMORY - 65 Kilobytes
DISK - 2.5 Million Bytes (2 floppy disks)
TERMINAL - CRT Display
PRINTER - 60 CPS Impact Printing

Additional or enhanced components for operation in more than one school or several programs might include:

SCANNER - Sheet Scanner SCANTRON (WAS DATUM) Optional
PRINTER - 180 CPS or Quality Impact Printer
DISK - 20 million bytes (cartridge hand disk)

Summary

The usefulness of the microcomputer for large-scale CMI has been demonstrated. The microcomputer, however, is not a $500 micro commonly available from retail microcomputer vendors. It is probably possible to implement this system on one of the smaller microcomputers, but a lot of effort would be required. Also, it is evident that the cost of the hardware to support this system on an ALTAIR, TRS-80, APPLE, CROMEMCO, PET, etc., will be roughly equivalent to the hardware represented by this effort.

Three school districts have participated in the pilot test of MICRO-CMI. They include the McFarland elementary schools, the Twenty-First Street School in Milwaukee, and thirteen elementary schools in Danville, Illinois. The McFarland schools employ the system for five different curricular areas including reading, math, science, social studies, and physical education. The other schools employ the system to maintain records in their individualized

reading programs. Responses from users are supportive. The system in McFarland is an integral part of the daily classroom decisions. Students are grouped in all subjects every two weeks, and reports keep teachers, parents, and students informed of student progress. The computer system in Danville maintains records for the district's inventory and teacher inservice records in addition to regularly producing reports and student information. Milwaukee is planning to add Franklin Elementary School's reading program to the computer system at Twenty-First Street School.

The hardware components used for the system in McFarland cost the district $12,500. For that price they have 3.75MB of reliable floppy disk mass storage, high speed CRT display, and a 60 CPS printer. The cost of a system with 2.5MB of mass storage can be acquired for approximately $10,000. Highly sophisticated small business computers sell for the same amount.

Moreover, the computer system which supports the CMI application is far more than just a CMI engine. It is a general purpose computer capable of supporting sophisticated statistical analysis, accounting procedures, word processing, or Computer Aided Instruction. This paper is not intended to explore the extent of the LSI-11 computing potential, but many shared computing applications can be identified. For most applications, there is already a large amount of software available.

MICRO-CMI demonstrates the viability of microcomputers in the schools performing the important classroom management information tasks that emerge with an individualized program. These individualized programs require extensive data collection and report generation. MICRO-CMI is designed to support these processes, and it is now apparent that this can be done in an efficient and cost effective manner.

Large scale computers can provide a CMI application, but typically the cost is great. The WIS-SIM program installed in Denver is a good example. Thirteen thousand dollars per school per year is more than most districts are willing to spend. It was estimated that the cost of running the TRACER CMI program for the Anchorage School District through a time-sharing service would cost $26,000 per year. The MICRO-CMI computer in the school offers on-line generation of results, reports, listings, and grading and operates far more efficiently that the normal time-sharing system.

The MICRO-CMI programs have been designed in a modular fashion which enables the addition of new functions with a minimum of effort. The driving program requires modification to include such additional routines as attendance accounting or mailing label generation. Clearly, the technologies of the future will incorporate more and more

use of microcomputers. MICRO-CMI offers a comprehensive step in that direction.

The computer programs are available for distribution on magnetic tape. They are coded in FORTRAN for a DEC LSI-11 using the RT-11 operating system. The listings are extensive, and the implementation of this system on other than Digital Equipment Corporation systems will be a difficult matter. Because of the nature of the programming techniques applied and the amount of mass storage required, attempts to implement this program on APPLE, TRS-80, or other small eight-bit computers is not recommended. Further information regarding the implementation of MICRO-CMI can be obtained from:

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Reference

McIsaac, D. & Baker, F. MICRO-CMI Performance Specifications, September, 1978.